

# Home Automation System using ZigBee and PandaBoard as a Gateway (HAS-ZP)

Ankit Patel<sup>1</sup>, Himanshu Prajapati<sup>2</sup>, Hardik Sheth<sup>3</sup>, Ekata Mehul<sup>4</sup>

<sup>1,2,3</sup> Pursuing M.Tech., Embedded System, U.V.Patel college of Engineering and Technology, Kherva, Mehsana, India  
avpatel90@gmail.com, himanshu.ec1987@gmail.com, hardik.ec0752@gmail.com

<sup>4</sup>Head eiTRA - eInfochips Training and Research Academy, Ahmedabad  
ekata.mehul@eitra.org

**Abstract**— Today's homes have as many wires as the number of devices to control. Home automation using ZigBee and PandaBoard as a gateway does away with the need for separate wires and even remotes. The wireless home area network doesn't require line-of-sight communication. The HAS-ZP is a wireless home automation system that can be implemented in existing home environments, without any changes in the infrastructure. Home Automation lets the user control the home appliances from his or her smart-phone or laptop. The assigned actions can happen depending on time or other sensor readings such as light, temperature or sound from any connected device in the Home Automation network. With the help of PandaBoard, currently working as gateway, we can control, command, operate and observe the end devices. Here we are considering end devices like fan, bulb, TV, Music System, doors, windows etc. with the single gateway, the system can control entire home irrespective of number of rooms or boundaries where each room will be connected with single receiver.

**Index Terms**— Embedded System, Home Automation, Microcontroller (8051), PandaBoard, Web Server Application, ZigBee

## I. INTRODUCTION

In 21st Century, with the advent of new technologies almost every day, the living standards and comfort level of people has reached a very high level. A large part of the modern lifestyle is usage of electronic and electrical devices.

Today various wireless technologies are used with the help of which one can monitor the status of the devices as well as control the same. The technology known as "ZigBee Technology" is superior to Bluetooth, Infrared and Wi-Fi technology in terms of Home Automation Systems which requires low data rates and ZigBee is a low cost, low power, wireless mesh networking standard[2],[3]. ZigBee can control  $2^{16}$  devices at a time and has the data transfer rate of 250kbps. ZigBee is also compliant with IEEE 802.15.4-2003 standard. The PandaBoard is a low-power, low-cost single-board computer development platform based on the TI OMAP4430 system on chip (SoC). The chip is targeted to run an OS and more traditional desktop style applications also work as a PC.[1]

## II. SYSTEM OVERVIEW & FUNCTIONAL DIAGRAM:

This is the functional diagram of HAS-ZP. Here the system mainly divided into three parts as shown in below figure 1:

DOI: 01.IJRTET.10.2.4

© Association of Computer Electronics and Electrical Engineers, 2014

(i) It contains Gateway and Wireless trans-receiver. Here PandaBoard working as a gateway or server to handle and to monitor each appliance in the home, in the other hand ZigBee is working as a coordinator which transmits & receives commands from PandaBoard to the end devices wirelessly. (ii) It contains End Appliance, Microcontroller & ZigBee, where it works as a slave. It receives data from the coordinator & transmits it to the 8051 micro-controller. 8051 micro-controller processes the data, relatively commands the end appliance(s) (e.g. fan, ac, bulb, door etc.) and transmits the feedback data to the gateway. (iii) It consists of any smart phone or laptop or tablet which has the facility of internet connectivity to access the appliances with the graphical interface of the application far from the home [6].

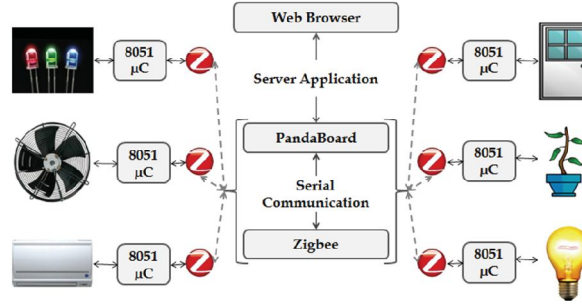


Figure 1. System Overview

## II. HARDWARE DESIGN

This section is focused on hardware design parting in two where first part contains the gateway side and other one is end appliances or slave side.

### A. Gateway System with PandaBoard:

Figure 2 shows the Gateway setup, where ZigBee is connected with the PandaBoard. To control or monitor the output we have taken LCD monitor with the HDMI support which is connected to PandaBoard with the HDMI cable. It's not mandatory; you can use USB to serial cable and see the output in your current PC. For memory PandaBoard supports SD Card in which the Ubuntu OS is ported. For internet connectivity we can use PandaBoard's inbuilt Wi-Fi or LAN port. For user interface we can use mouse & keyboard. If we use USB to serial cable then it will not require.

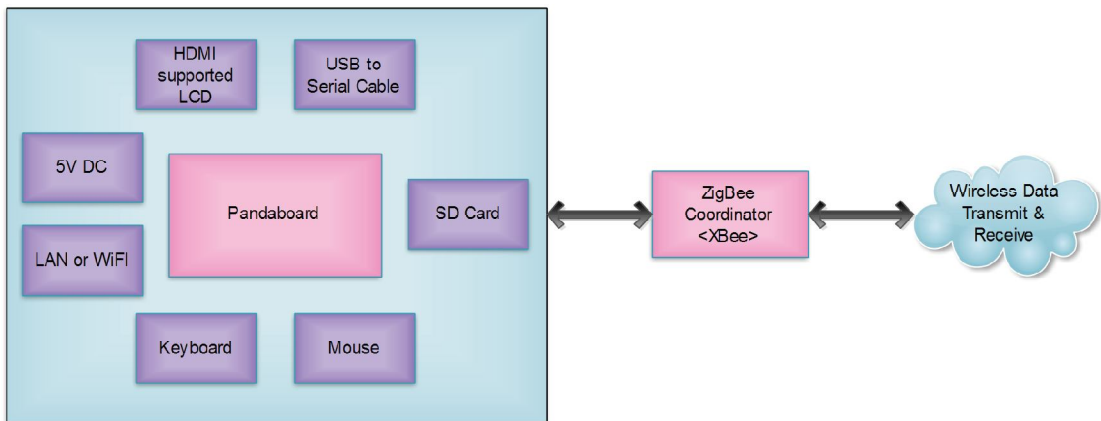


Figure 2. Block Diagram of Gateway System with PandaBoard

### PandaBoard:

The OMAP4430 SOC on the Panda Board features a dual-core 1 GHz ARM Cortex-A9 MPCore CPU, a 304 MHz PowerVR SGX540 GPU, a C64x DSP, and 1 GB of DDR2 SDRAM. PandaBoard supports many types of OS like Ubuntu, Android, Palm OS, Symbian OS but we are using Ubuntu because of its flexibility.

### *ZigBee:*

ZigBee is intended as a specification for low-powered networks for such uses as wireless monitoring and control of lights, security alarms, motion sensors, thermostats and smoke detectors. ZigBee networks are secured by 128 bit encryption keys.

### *ZigBee Networking Concepts:*

**Coordinator:** This device starts and controls the network. The coordinator stores information about the network, which includes acting as the Trust Centre and being the repository for security keys. It Selects a channel and PAN ID (both 64-bit and 16-bit) to start the network. It can allow routers and end devices to join the network. It can assist in routing data. It cannot sleep--should be mains powered. It can buffer RF data packets for sleeping end device children.

**Router:** These devices extend network area coverage, dynamically route around obstacles, and provide backup routes in case of network congestion or device failure. They can connect to the coordinator and other routers, and also support child devices

**End Devices:** These devices can transmit or receive a message, but cannot perform any routing operations. They must be connected to either the coordinator or a router, and do not support child devices. It must join a ZigBee PAN before it can transmit or receive data. It cannot allow devices to join the network. It must always transmit and receive RF data through its parent. It cannot route data. It can enter low power modes to conserve power and can be battery-powered.

Here for implementing ZigBee protocol we are using modules like XBee and XBee - Pro from Digi-International. According to your need in terms of range and price we can select any one from them.

### *B. End Appliances Control System*

As per figure 3 we have set up end appliance control system. Setup is based on the block diagram which is in figure 4. We have modeled three rooms and a kitchen for our setup. Each room contains one XBee along with controller circuit. In some room we are controlling appliance like bulb or light's intensity & fan speed using dimmer circuit. In some room we are controlling devices with relays.

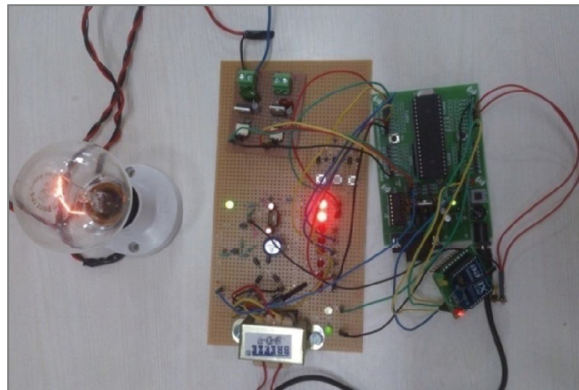


Figure 3. Snapshot of End Appliance System

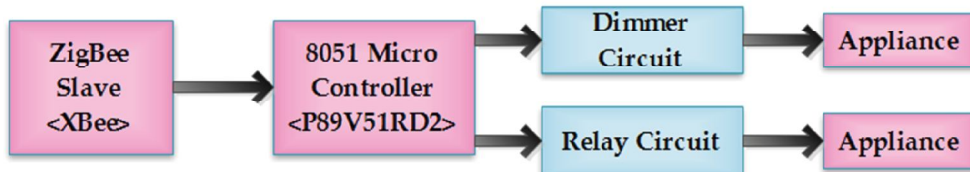


Figure 4. Block Diagram of End Appliances

## III. SOFTWARE DESIGN

As we are considering two parts here Gateway system with PandaBoard & End Appliances Control System. In the gateway side we have to program PandaBoard as per figure 5 to work like below.

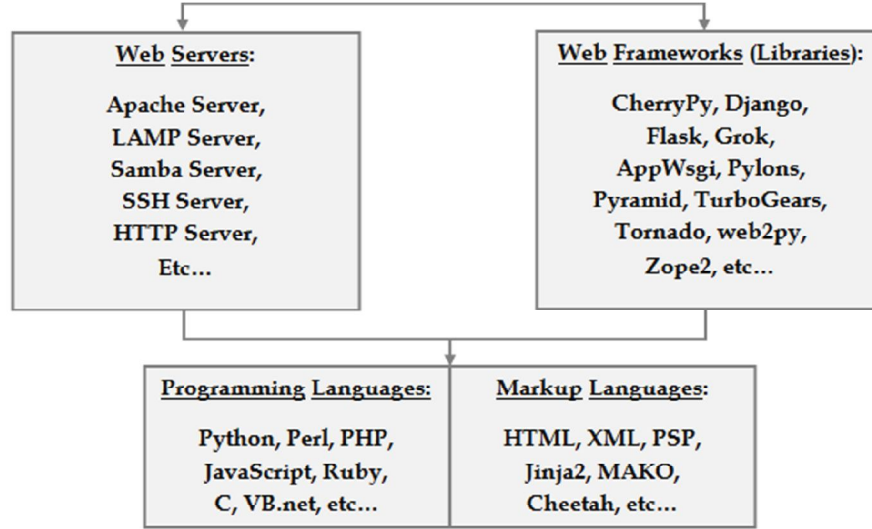


Figure 5. Working flow of PandaBoard

A web application consists of parts that reside on a server and parts that run on the computer of the user (client). The server may hold the application data and implement the logic to modify that data following requests from the user, the data is displayed by the part of the web application running in the browser on the client computer and the user signals his/her request by interacting with the user interface components in the browser.

A server-side application services request the server & passes through the web server. The web server forwards those responses to the client again and may serve static files as well. The web browser takes care of run process at the client side of the application, but within the browser, we can identify several layers of activities. These consist of: Fetching the content to structure the data (often HTML files). Run JavaScript codes to enhance the presentation of the data [4]. Allow the interaction with the user.

To deliver information to the client and receive a response in return, our web application needs two important items at the server: a delivery framework and an application to compose content and response to the request. The delivery framework might be a full-fledged general purpose web server such as Apache, LAMP, Samba or Microsoft Information Server [13]. These are very versatile and come with many options to tune the web server to our specific needs. They certainly take extra attention to integrate the dynamic content of our application with these servers. If performance is crucial or the requirements for project include that application has to be deployed as part of these servers then we have to choose one of that, but otherwise it's worth looking at the alternatives that are simpler to use or offer integration advantages using Python web-application libraries [5], [16], [17].

#### A. End Device Application

At the other part of End Appliances Control System we have used NXP's P89V51RD2 micro-controller to control any appliance in home. Server or gateway commands the end devices to do specific task of controlling the appliances or switch ON or OFF the appliances. When it commands through ZigBee coordinator at that time specific slave ZigBee according to end address defined by the coordinator fetches the data & pass the data to attached micro-controller. Micro-controller then command any end appliance based on fetched data.

#### IV. WORKING OF HAS-ZP

Here we are using PandaBoard as a gateway. Below snapshot gives the idea of setup at the gateway side. To access and control the end appliance we have to use web browser which supports html through any smart devices (e.g. Mobile Phone or Tablet or PC). Type the IP address with its port number or if you have registered your domain then type the domain name in address bar. The domain name is already defined in the configuration file which will lead user to access the GUI of HAS-ZP. To access the specific appliance then

you have to go through the GUI on the browser and respective logs are also available at the gateway side. Errors can also be identified by current logs which are shown in Appendix [B]. So through that we can resolve the error.

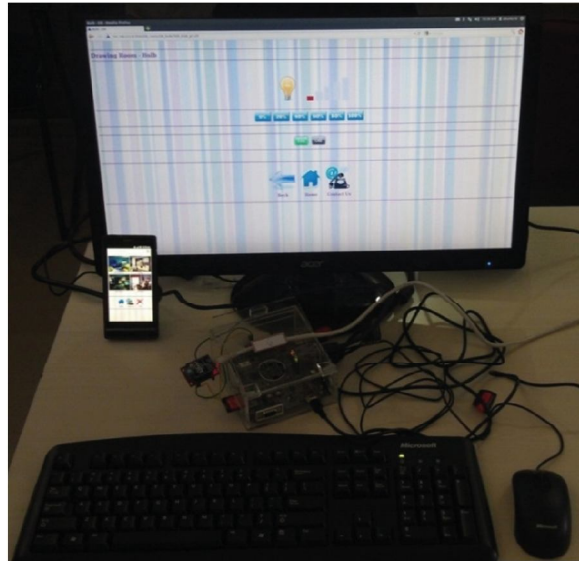


Figure 6. Snapshot of Gateway Setup

Figure 6 shows the Ported OS the PandaBoard, the images were downloaded [7], [8] and install from [9], [10]. When user access appliance from GUI, gateway transmits the command to end device which will process by 8051 micro-controller. 8051 micro-controller will access the appliances according to the command transmitted by gateway [14], [15]. One or more appliances from different rooms can also be accessed from GUI. The serial communication can be access through [11], [12].

## V. CONCLUSIONS

Home Automation using ZigBee and PandaBoard as a gateway serves as a reliable and efficient system for controlling the end devices. Wirelessly controlling and monitoring of devices not only allows users to control it from on site by PandaBoard which is the gateway or user can control it far away from the place wirelessly. Due to flexibility of PandaBoard we can port operating systems like Android OS and Ubuntu OS and extend usability of it. By the use of GPIOs & other pins we can interface more devices with it and also control them.

## VI. FUTURE WORK

Rather than using this at home but also migrate it for the corporate world. Handling & monitoring major components like water pumps, turbines etc. with just one click using any hand held devices. Time triggered or Real Time Applications like Auto water irrigation for plants based on specific time or more.

## VII. APPENDIXA APPLICATION LAYOUTS

Figure 7 contains the snapshots taken from the LCD screen which is connected with PandaBoard using HDMI cable. It shows the working of web based application to control all the appliances in the home and can be access far From the home.

## VIII. APPENDIX B LOG MESSAGES

Figure 8 is the flow diagram of applications which describes current status or commands coming from the master (Gateway) as well as slaves (End Devices). So from that we can understand the status of our appliance.



Figure 7. Layout of Application

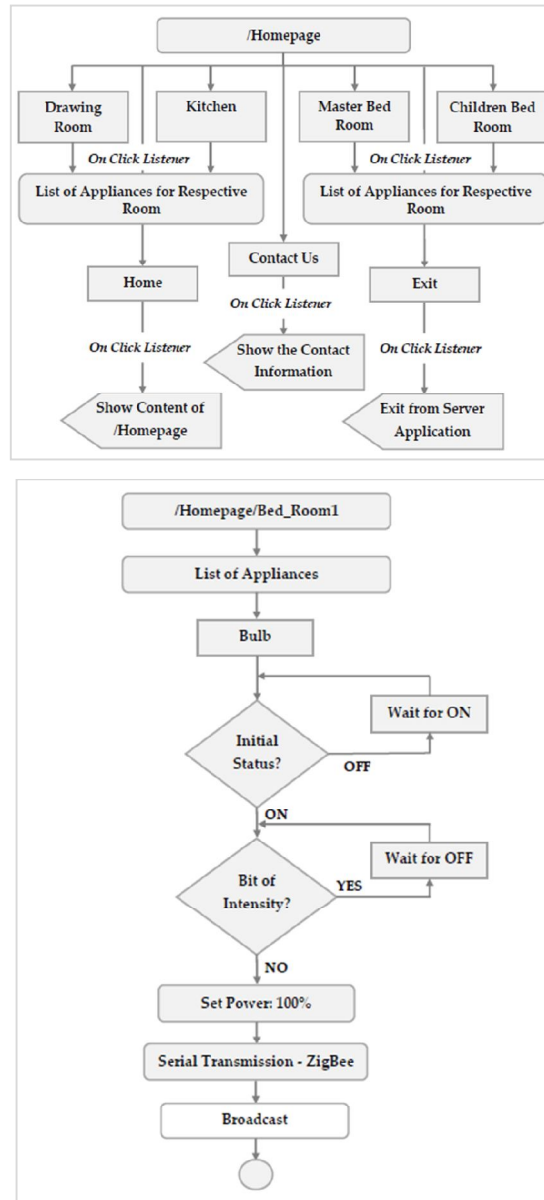


Figure 8. Flow of Application

#### IX. APPENDIX C TEST - APPLICATION

Figure 9 shows the snapshots taken from the LCD screen for Accessing and Controlling the Drawing Room Bulb along with its Hardware Setup snapshot and its respective Console Messages. Here all the snapshot shows the response at 20% intensity of the drawing room bulb. So through that we can test our application and Hardware setup.



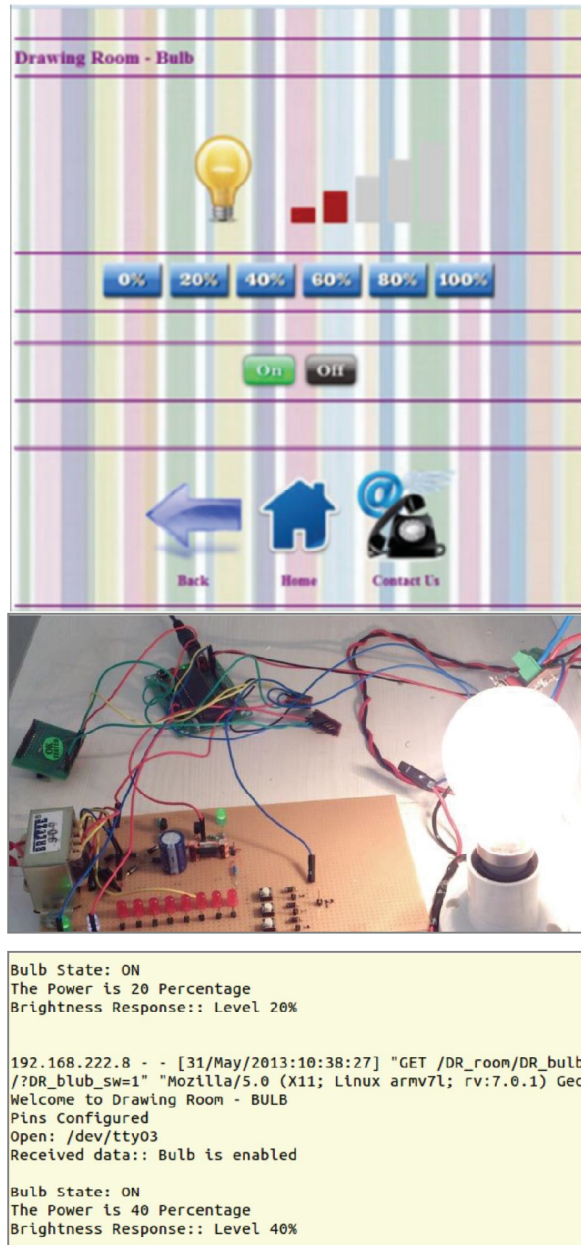


Figure 9. Application and Hardware Testing with its GUI and Log Messages

#### REFERENCES

- [1] Geoffrey Blake, Ronald G. Dreslinski, and Trevor Mudge, "A Survey of Multicore Processors," IEEE SIGNAL PROCESSING MAGAZINE, pp. 26-37, NOV 2009.
- [2] Michal Varchola, Milos Drutarovsky, "ZigBee Based Home Automation Wireless Sensor Network," Acta Electrotechnica et Informatica No. 4, Vol. 7, 2007
- [3] Khusvinder Gill, Shuang-Hua Yang, Fang Yao, and Xin Lu, "A ZigBee-Based Home Automation System," IEEE Transactions on Consumer Electronics, Vol. 55, No. 2, MAY 2009
- [4] A.R. Al-Ali, Member, IEEE & M. AL-Rousan, "Java-Based Home Automation System," IEEE Transactions on Consumer Electronics, Vol. 50, No. 2, MAY 2004



- [5] Amul Jadhav, S. Anand, Nilesh Dhangare, K.S. Wagh, "Universal Mobile Application Development (UMAD) On Home Automation," Network and Complex Systems, ISSN 2224-610X(Paper) ISSN 2225-0603(Online), Vol2, No.2, 2012
- [6] A. Alheraish, Member, IEEE, "Design and Implementation of Home Automation System," IEEE Transactions on Consumer Electronics, 1088 Vol. 50, No. 4, NOVEMBER 2004
- [7] To download the desktop or Server based image follow link, NOV 2013 :  
<http://cdimage.ubuntu.com/releases/12.04/release/>
- [8] To install or upload the Image for Pandaboard follow link, NOV 2013:  
[http://pharos.ece.utexas.edu/wiki/index.php/How\\_to\\_Install\\_Ubuntu\\_on\\_the\\_Panda\\_Board](http://pharos.ece.utexas.edu/wiki/index.php/How_to_Install_Ubuntu_on_the_Panda_Board)
- [9] For TI OMAP new release update follow link, NOV 2013:  
[http://omappedia.org/wiki/Installing\\_Ubuntu\\_12.04\\_on\\_PandaBoard\\_with\\_TI\\_ppa](http://omappedia.org/wiki/Installing_Ubuntu_12.04_on_PandaBoard_with_TI_ppa)
- [10] To upload the pre-built binaries of Ubuntu on Pandaboard follow, NOV 2013 :  
[http://omappedia.org/wiki/PandaBoard\\_Ubuntu\\_Pre-built\\_Binaries\\_Guide](http://omappedia.org/wiki/PandaBoard_Ubuntu_Pre-built_Binaries_Guide)
- [11] UART access procedure for BeagleBone with XBee for serial communication follow link, NOV 2013 :  
<http://www.jerome-bernard.com/blog/2012/06/04/beaglebone-serial-ports-and-xbees/>
- [12] To Access the Multiplexed Pins for single functionality follow, NOV 2013 :  
<http://www.gigamegablog.com/2012/01/22/beaglebone-coding-101-using-the-serial-and-analog-pins/>
- [13] List of Web Frameworks to create a web based Application, NOV 2013 :  
<http://wiki.python.org/moin/WebFrameworks>  
To access the Serial communication over Web APIs need one backend which supports python for detail follow, NOV 2013: <http://pyserial.sourceforge.net/pyserial.html>
- [14] Support for 8051 programming and Hardware based support on end device follow, NOV 2013 :  
<http://www.8051projects.net>
- [15] Support for 8051, AVR and PIC controller programming and Hardware based support on end device follow, NOV 2013 : <http://www.engineersgarage.com/>
- [16] Michel Anders, "Python 3 Web Development: Beginner's Guide," Published by Packt Publishing Ltd., ISBN 978-1-849513-74-6, May 2011, Production Reference: 1060511
- [17] Sylvain Hellegouarch, "Cherrypy Essentials: Rapid Python Web Application Development," Published by Packt Publishing Ltd., ISBN 978-1-904811-844-8, March 2007, Production Reference: 2220307